2

Energizing the Trinity: Operational Implications of Warfare in the Age of Information Technology

A Monograph
by

Major John K. Stoner

Armor

School of Advanced Military Studies
United States Army Command and General Staff College
Fort Leavenworth, Kansas

Second Term AY 92-93

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
14/05/93

3. REPORT TYPE AND DATES COVERED
MONOGRAPH

4. TITLE AND SUBTITLE
ENERGIZING THE TRINITY: OPERATIONAL IMPLICATIONS OF WARFARE IN THE AGE OF INFORMATION TECHNOLOGY.

5. FUNDING NUMBERS

6. AUTHOR(S)
MAJ JOHN K. STONER, USA

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
SCHOOL OF ADVANCED MILITARY STUDIES
ATTN: ATZL-SWV
FORT LEAVENWORTH, KANSAS 66027-6900
COM (913) 684-3437 DSN 552-3437

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
SEE ATTACHED.

14. SUBJECT TERMS
INFORMATION TECHNOLOGY; CLAUSEWITZ; COMMUNICATIONS TECHNOLOGY; CHAOS THEORY

15. NUMBER OF PAGES
53

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	

ABSTRACT

Title: ENERGIZING THE TRINITY: OPERATIONAL IMPLICATIONS OF WARFARE IN THE AGE OF INFORMATION TECHNOLOGY by MAJ John K. Stoner, USA, 53 pages.

This monograph examines the cumulative effect which improvements in information technology have had at the operational level of war. Specifically, it uses the Clausewitzian theory of war to analyze how modern methods of information processing and communication increase the influence of national policy in military operations.

The monograph is introduced with a brief survey of the ways in which both the international political economy and military operations have changed as a result of the Third Industrial Revolution of high technology. It goes on to show that innovations in military and information technology have dramatically changed the manifestations of modern war. The question of whether the doctrine of extremes is flexible enough to accomodate these changes in information technology is then posed.

A thorough review of the trinity of war follows the introduction and establishes the theoretical foundation for the argument. A brief examination of the convergence of weapons and information technology shows that war has adapted to the dominant features of the Information Age, creating a technological trinity of post-industrial warfare. Chaos theory is then introduced as a means to provide insight into the transformed manifestations of modern war.

From this baseline the monograph analyzes the practical application of Clausewitz's theoretical construct at the tactical, strategic, and operational levels of war. An in-depth case study from Desert Storm demonstrates that the cumulative effect of improvements in information technology yields precise command direction by national policymakers in military operations. The resultant product of these technological interactions is a new type of unexpected friction at the operational level of war.

Finally, the monograph focuses on the implications of precise command direction for operational warfare in the future. It ends on a cautionary note, suggesting that while theory is flexible enough to incorporate these developments our warfighting doctrine and force structure must also keep pace.

SCHOOL OF ADVANCED MILITARY STUDIES

MONOGRAPH APPROVAL

Major John K. Stoner

Title of Monograph: Energizing the Trinity: Operational Implications of Warfare in the Age of Information Technology.

Approved by:

Dr. Roger Spiller, Ph.D. — George C. Marshall Professor of History, Monograph Director

COL James R. McDonough, MS — Director, School of Advanced Military Studies

Philip J. Brookes, Ph.D. — Director, Graduate Degree Program

Accepted this 14th day of May 1993.

ABSTRACT

Title: ENERGIZING THE TRINITY: OPERATIONAL IMPLICATIONS OF WARFARE IN THE AGE OF INFORMATION TECHNOLOGY by MAJ John K. Stoner, USA, 53 pages.

This monograph examines the cumulative effect which improvements in information technology have had at the operational level of war. Specifically, it uses the Clausewitzian theory of war to analyze how modern methods of information processing and communication increase the influence of national policy in military operations.

The monograph is introduced with a brief survey of the ways in which both the international political economy and military operations have changed as a result of the Third Industrial Revolution of high technology. It goes on to show that innovations in military and information technology have dramatically changed the manifestations of modern war. The question of whether the doctrine of extremes is flexible enough to accomodate these changes in information technology is then posed.

A thorough review of the trinity of war follows the introduction and establishes the theoretical foundation for the argument. A brief examination of the convergence of weapons and information technology shows that war has adapted to the dominant features of the Information Age, creating a technological trinity of post-industrial warfare. Chaos theory is then introduced as a means to provide insight into the transformed manifestations of modern war.

From this baseline the monograph analyzes the practical application of Clausewitz's theoretical construct at the tactical, strategic, and operational levels of war. An in-depth case study from Desert Storm demonstrates that the cumulative effect of improvements in information technology yields precise command direction by national policymakers in military operations. The resultant product of these technological interactions is a new type of unexpected friction at the operational level of war.

Finally, the monograph focuses on the implications of precise command direction for operational warfare in the future. It ends on a cautionary note, suggesting that while theory is flexible enough to incorporate these developments our warfighting doctrine and force structure must also keep pace.

TABLE OF CONTENTS

During a twenty-five minute break from their April 1987 strategic arms discussions in Moscow, Secretary of State George Shultz gave Soviet leader Mikhail Gorbachev a brief tutorial on economic interdependence in the Information Age. Shultz focused his comments on the changed dimensions of the global marketplace and the poor performance of the Soviets in the international economy.

Shultz wanted to convince Gorbachev that flows of capital, manufactured goods, people, and information have increased to such an extent that political and economic relations between modern states are radically different from those which dominated the Cold War. The classical models of inter-state rivalry among independent countries have been largely overtaken by economic interdependence in a world marketplace unconstrained by historical national boundaries.

The cause of these dramatic changes was the Third Industrial Revolution of high technology, in which "ideas and information had become key to scientific and economic progress."[1] Shultz wanted to show Gorbachev that the U.S.S.R. was in grave danger of excluding itself from the revolution, "which had scarcely a toehold in the Soviet economy outside the military sector."[2] The problem was the political and technological capacity of Soviet society. It could not promote the flow of information necessary for competition in the modern global marketplace. The Soviets had taken few steps to rectify this shortcoming.

As evidence Shultz cited the fact that a single day's transactions in the world's financial markets was worth over $1,000,000,000,000.00 — "more than the entire budget of the U.S. government for a year."[3] The sheer volume of that financial trade points directly to the crucial need for modern states who hope to prosper to actively participate in the global economy. Yet the Soviet share of all world exports was only two percent -- a minuscule amount when compared to the potential productive capacity of the U.S.S.R.

Gorbachev had ample reason to listen closely. He had watched the performance of the Soviet economy sputter into stagnation and he shared Shultz's views about not "preserving [Soviet] technological backwardness."[4] But the Soviets were simply not technologically prepared to take advantage of the Third Industrial Revolution. Rough estimates indicated that there were approximately 200,000 "utterly unsophisticated" microcomputers in the Soviet Union in 1987, compared to over 25 million in the United States.[5] But even if the computers had been available most of the Soviet telecommunications system -- "the key to rapid flow and use of available information"[6] -- was incapable of handling digital data traffic.

Having the requisite hardware was just one part of the problem. Shultz warned that in the future Gorbachev's country could not continue to purposefully wall itself off from the domestic and international flow of public information. The successful states of the future will be those which can best adapt to the porous, interconnected nature of global politics in the Information Age. Achieving this transformation would mean a major shift in attitudes about the openness of Soviet society. Yet until they initiated such fundamental change, the Soviets could not possibly improve their capacity to rapidly process and disseminate information. Unless they could catch up to the Third Industrial Revolution, they would never be able to improve both their domestic economy and their opportunities to prosper in the global economy.

Gorbachev obviously took Shultz's ideas seriously. When he published his best seller Perestroika later that same year, he wrote that this "is a world of fundamental social shifts, of an all-embracing scientific and technological revolution ... and of radical shifts in information technology."[7] He agreed that the Soviet Union had to adapt quickly to the new conditions of the technologically dominated international economy.

The most pervasive changes which have propelled the Third Industrial Revolution of high technology have been in the realm of information processing -- the ability to collect, purposefully manipulate, disseminate, and utilize information rapidly. Consider, for example, that a typical computer forty years ago cost $500,000, took up more than 500 cubic feet and required nearly 30,000 watts of power to run. An equally powerful silicon chip today measures only "1/4-inch square and 15-thousandths of an inch thick, costs $50, and consumes 5 million times less power."[8] The fiber optic lines which are used in telecommunications systems are so efficient "that a one-mile-thick piece can transmit light at least as well as a common windowpane."[9] Imagine that just a single pair of hair-thin fiber optic cables can simultaneously carry over 20,000 telephone conversations.[10]

It is not an overstatement to suggest that these advancements affect us every day. Consider the accuracy of the inexpensive digital watches which many now wear, the growing efficiency and power of personal computers, or the latest portable phones which fit neatly in a shirt pocket. The burgeoning popularity of Cable News Network (CNN) is ample proof that contemporary society has acquired a taste for up to date information presented as rapidly as possible.

The dynamics of information processing and communications means have also changed at a breathtaking rate in the realm of military technology. Airborne command posts can simultaneously control the deployment of friendly forces and monitor movements of the enemy well behind the forward line of troops. Commanders perceive the battlefield with intelligence updates from reconnaissance teams who relay their reports by satellites in geosynchronous orbits. Those same soldiers use lasers to target bridges and railroads which are then destroyed by artillery rounds fired from distances of several miles.

Military command and control systems now process data and transmit messages along multiple dimensions in near real time. At the height of the Gulf War conflict, "the automated message-information networks passed nearly 2 million data packets per day through gateways in the Southwest Asia theater of operations."[11] Successively higher commanders use newly fielded automated systems to gain access to more and more information about their subordinates' activities at ever lower levels of responsibility. Simply put, dramatic improvements in technology which began as long ago as the Industrial Revolution have fundamentally altered the role which information plays in modern warfare.

There have also been impressive technological changes in the domain of military weaponry, as demonstrated during the recent conflict in the Persian Gulf.

Tank main guns now accurately engage stationary targets at ranges of up to four kilometers. Precision guided munitions deliver powerful explosive ordnance over extended distances with breathtaking accuracy. Jet aircraft provide close air support to mechanized units fighting widely dispersed on non-linear battlefields. Heat-seeking missiles fired by individual infantrymen in self defense can knock those same airplanes out of the sky.

Although this brief survey demonstrates a vast technological leap forward from the methods of war used in the 19th century, it does not even mention the extraordinary lethality of nuclear, biological, and chemical weapons. Consider, for example, the potentially devastating effects of a thermonuclear first-strike on unwarned cities in India. Or imagine the insidious, incalculable long term results of a biological attack on the agricultural heartland of Western Europe combined with a persistent chemical agent strike against the industrial societies in the same region. As close to "its absolute state"[12] as the violence of Napoleonic warfare was, it certainly could never match the nearly instantaneous destructive standards set by these modern weapons of mass devastation.

Therefore, as Antoine Henri Jomini wrote, "the means of destruction are approaching perfection with frightful rapidity."[13] Commanders and their armies now have far more powerful means with which to pursue the strategic goals of war. The spiral of violence which accompanies most modern conflict can bring combatants to the brink of absolute war with astonishing speed -- far more rapidly than was the case in the early 1800's.

These innovations give operational commanders the ability to greatly increase the destructive, offensive capability of their forces by massing weapons effects against less capable opponents. When combined with highly lethal weaponry, the ability to rapidly process and utilize information gives modern war an almost instantaneous character. The sum total of these developments has changed the manifestations of war in the post-industrial Information Age; the dynamics of war are different now from any we have previously observed.

The purpose of this paper is to examine the cumulative effect which these improvements in information technology have had at the operational level of war. Clausewitz wrote that "the form taken by a war" is a result of "those features that happen to be dominant"[14] during a given period of history. In other words, war *moves* in concert with the defining characteristics of a specific age. Since Clausewitz's era, technology has been the most dominant force which has caused war to *move* through time.[15] The dynamics of information technology now dominate the form of war in the Information Age, causing war to *move* again.

Can the trinity of war first described over 150 years ago in Book One of On War accommodate these changes in modern information technology? Perhaps the defining characteristics of war in the post-industrial Information Age will force theorists to go beyond the Clausewitzian theory of war in order to better understand modern conflict. Or is theory flexible enough to incorporate information technology? A logical starting point for analysis is the text of On War itself.

A Return to the Basics -- the Trinity of War

Clausewitz described war as a relationship between three dominant tendencies. His theory conceived of the total phenomenon of war as

> a paradoxical trinity -- composed of primordial violence; .... of the play of chance and probability within which the creative spirit is free to roam; .... and of its element of subordination, as an instrument of policy, which makes it subject to reason alone.[16]

The explanatory power of this concept lies in the variable, limiting relationship which the three tendencies have with one another. Should the actions of a war's belligerents not be constrained by the play of chance, probability and friction, or should their policy not remain subordinated to reason, war would become an "untrammeled, absolute manifestation of violence."[17] The character of the war would burst directly from the primordial violence and hatred of the nations which wage it. The interaction of Clausewitz's dominant tendencies is therefore critical, for if the limitations inherent in the relationship between these tendencies are not at play, war must logically tend toward the theoretical extremity of absolute war.

The most important of these forces, of course, is the political object which establishes the goal of the war. Clausewitz viewed war as a political instrument which gains its essence from the dynamic interactions between the dominant tendencies. War is therefore a trinity which remains suspended in balance between the "three magnets" of policy, primordial violence, and chance. He warned that "the supreme, the most far-reaching act of judgment"[18] of statesmen and commanders is the test which establishes the type of war on which a nation embarks. This determination -- regarding the ends which a nation seeks to achieve -- dictates the means a state must use to achieve its political end. It also frames the potential character of the war itself, since the most important ends may demand more violent means.

Theoretically, Clausewitz posited, there should be "no logical limit to the application"[19] of force in war. However, he also observed that combat never actually reached that theoretical limit of absolute war because the relationship between reason and chance and the effects of friction served as controls which constrained the violence of the participants. The same condition holds for both combatants. Since war is "always the collision of two living forces,"[20] its participants become entangled in a dynamic relationship during the period of conflict.

If the interaction of reason and chance and the influence of friction do not constrain the behavior of the belligerents, their relationship can become a spiral of increasing violence which tends toward absolute war. In fact, this tendency will accelerate if the goals of the Army (in the realm of chance) and the State (in the realm of reason) converge and the retarding effects of friction are reduced.

In other words, the level of violence which characterizes a particular conflict changes during the war, chameleon like, as a result of the interaction of Clausewitz's dominant tendencies. Should this spiral of violence be allowed to pulse unchecked, there would be no logical limit to the efforts each side might take to overcome their enemy. The nature of the war itself would change as both combatants grasp at ever more violent and extreme means in their efforts to win. At the end of the war, one might not even recognize a clear link between the strategic goals established at the beginning of the war and the means in use near its conclusion. Unintended consequences can become the product of belligerent efforts which grow in intensity as the conflict stretches along. At the end of World War I, few of the belligerents were greatly concerned about the assassination of an archduke.

Back to the Future -- A Technological Trinity

The increased danger of warfare in the contemporary era lies in the possibility that the additional technological energy contained in the trinity may cause interactions during war to take place too rapidly. The energy which causes this technological acceleration therefore threatens to break loose from the constraints of reason and chance in an instantaneous "real explosion"[21] of violence. When the dynamic, limiting relationship which the dominant tendencies have with one another is upset, modern technological violence can pulse unconstrained toward pure hatred and enmity faster than was ever possible. And the potential effects of such a conflagration on human societies could be far worse far faster than Clausewitz envisioned in On War. Modern war can be far worse because the massed effects of modern weaponry possess a destructive capacity unimagined in Clausewitz's era. It can happen far faster because technology accelerates the process exponentially.

Information technology adds yet another dimension to modern war. In the 1800's, news about events on the battlefield often took considerable time and effort to collect. Once gained, such information could then be used to take decisions and issue orders for the next phase of the battle -- but the entire process still retained a sequential character. The means with which leaders could influence events at the front line were limited by the communication and control methods available at that time in history. Theoretically, then, the speed with which interactions between Clausewitz's dominant tendencies occurred was defined by the limitations inherent in each action-reaction-counteraction sequence.

Clausewitz addressed this issue when he analyzed the distinctions between abstract war and war in the real world. One condition of the real war he observed was that it did not consist "of a single decisive act or a set of simultaneous ones."[22] If it did, he warned, preparations for war would tend toward totality and be less responsive to reason. In other words, as technology improves and the methods of modern war enable synchronized operations, the very nature of war as Clausewitz described it threatens to change.

The sequential character of war has in recent years been compressed to near real time by modern methods of information processing and data fusion. Decisions which once took days to disseminate can now be communicated in only seconds (see the attached Figure 1). Events which have traditionally been separated in time and space now take place nearly simultaneously. The effects of friction on efforts to combine combat power are also different as a result of this increase in operations tempo. The element of time, which once interfered directly with operations and increased friction in combat, is now greatly reduced. Commanders can design their operations to exploit the increased agility of their forces and the decreased reaction time of less capable opponents. Operations tend more and more toward simultaneity.

Paradoxically, just as the convergence of weapons and information technology can potentially propel war more rapidly toward its theoretical absolute, statesmen can also use information technology to dampen the blind natural force of hatred and enmity. The uneasy balance of nuclear terror in the 1960's motivated the establishment of secure communications between the U.S. and Soviets to prevent misunderstanding and nuclear war. Additionally, modern countries now use satellite imagery to verify compliance with chemical and nuclear test ban treaties.

Potential belligerents on the brink of war communicate with each other unofficially through the headlines of CNN. In How CNN Fought the War, for example, Perry Smith describes how then Secretary of Defense Dick Cheney sent "a powerful message to Saddam Hussein; that the Coalition might win the war with air power alone." Cheney wanted to convince Hussein not to "count on a ground war where there would be many American casualties."[23] So one finds that in addition to its potentially violent character, technology can also help reinforce the control inherent in the realm of reason.

Soldiers can thus become important instruments in war-ending. The final draft of the Army's new doctrine FM 100-5, Operations describes Army forces as "uniquely suited to postconflict operations" such as refugee handling and civil affairs, among others. It further states that after open conflict ends, commanders must emphasize nation assistance to stabilize the situation until "the Department of State or a host nation agency assumes control."[24] This is quite a contrast from conflicts in which victorious armies might choose to savage the population and country of a defeated nation.

The form taken by modern war in this theoretical context is a function of the feature which happens to be dominant during this period of history -- technology. Now, more than ever, technology is the major factor that will mold the shape of future wars. As has already been shown, information technology adds yet another dimension to modern war. The task of understanding these characteristics of Post-Industrial conflict falls to statesmen and military leaders. War has moved -- perhaps the trinity of Clausewitzian theory should, too.

A Changed Perspective -- The Chaotic View

Recent developments in information technology have been accompanied by what has been called "the century's third great revolution in the physical sciences,"[25] the advent of chaos theory. Although its name potentially invites confusion, chaos theory refers to a specialized body of scientific knowledge which has recently gained in popularity and importance. It examines initially unexpected outcomes in systems which change over time.

The science of chaos was first discovered in the field of dynamics,[26] and has produced a number of surprises in the work related to this field of inquiry. Where order has traditionally dominated, scientists can now also observe unanticipated experimental results which are quite complex; chaos started by upsetting Sir Isaac

Newton's laws of gravitation and motion. Recent scientific developments in the use of high-speed microcomputers, exceptionally precise experimental procedures, and novel mathematical methods have enabled researchers to re-evaluate the fundamental laws of nature.[27] It is now possible to show that "rigid, predetermined, simple laws can lead not only to predictable, everlasting pattern but also to behavior so complex and irregular that it appears to all intents and purposes random."[28]

Scientists exploring chaos have gained insights into a "newly recognized and ubiquitous class of natural phenomena"[29] in nature; systems that are too complex to analyze with traditional mathematics but which still obey simple laws. By proposing this new scientific view of the world, chaos has challenged the "deterministic, time-independent and universal laws enunciated in western European society during the seventeenth century."[30]

Thus, chaos theory calls directly into question some fundamental and comforting assumptions. For example, according to classical physics, the world is a machine which can be completely sequentially determined given enough accurate measurement and observation.[31] According to this changed perspective, though, the world is neither proportional nor additive[32]; one plus one does not necessarily equal two.

The focus of these research efforts is to better understand why events which have previously defied prediction from the perspective of linear causal analysis occur. For example, why is weather both so unpredictable and yet constant? What causes populations to grow and evolve as they do? Why is it not possible for a government to more accurately predict business cycles? Can one ever find two snowflakes which are exactly the same? Why not?

These unexpected outcomes occur in systems which are "nonlinear and sensitive to initial conditions."[33] Nonlinear refers to dynamic situations which change over time but do not obey the traditional laws of predictability. Instead, these systems produce complex and irregular results as a function of the interaction of their component parts. The relationship between the components becomes critical, since it helps define the range of possible outcomes.

Additionally, chaos theory holds that "a slight change in any one of the initial inputs leads to disproportionately divergent outcomes."[34] The patterns of activity which result from the interactions between the component parts depend on the situation and conditions which dominated their beginnings. In other words, sensitive dependence on initial conditions means that any small change in inputs can have a magnified effect on the life of the entire system.

Since they are dynamic in nature, chaotic systems are also sensitive to the passage of time. Events which occur at time t set the parameters for those which are feasible at time $t + 1$. This process cannot be reversed. Therefore, both the initial conditions and the relationships between the variables in a chaotic system are critical. But since such systems are by definition not linear, causal predictions cannot be made with certainty.

So What?

The link between chaos theory and the Clausewitzian doctrine of extremes may not at first glance be obvious. But it is a vital one. Chaos theory comprises a new theoretical lens through which to gain fresh insight into the interactions between the dominant tendencies of Clausewitz's "paradoxical trinity." The changed dynamics of war in the Information Age present unique problems in comprehension. Chaos provides the structure for an insightful analysis of the cumulative effect which improvements in information technology have had at the operational level of war.

The manifestations of modern warfare described earlier in this paper demand such an expanded framework for analysis. The conditions which contemporary soldiers face are radically different from those that dominated the battlefields of Clausewitz's era. Yet the trinity is flexible enough to incorporate these changes. Chaos theory is the critical link.

What is war, after all, if not a dynamic system which exhibits sensitive dependence upon initial conditions? Wars begin when states feel that their vital interests are threatened. In response to a perceived danger, they resist with all the means available to them. When a state chooses to take hostile action, its adversary helps set the initial conditions for the conflict. The participants then become entangled in a dynamic relationship which dominates their subsequent decisions.

When one of the belligerents modifies its policies to address the changing conditions of a war, the effects of those changed policies are often amplified in the response chosen by an opponent. Therefore, small changes in policy inputs are magnified during the course of war to produce unintended consequences. One need only think back as far as the Japanese strike against Pearl Harbor in 1941 to find a telling example of this tendency. The brutality with which soldiers fought on the islands of the Pacific was an unfortunate byproduct of that "sneak attack" and the primordial hatred which resulted from it. In December 1944, for example, almost half of the Americans polled wanted to either "kill all Japanese" or destroy Japan as a political entity after the war.[35]

Theoretically, these unanticipated events are products of the interactions between Clausewitz's dominant tendencies. As primordial violence, the play of chance, and the influence of policy affect one another during the course of war, they form patterns of activity. These patterns, and the shapes they describe, comprise the character of the war. The obvious problem is that, unlike the predictable proportional and additive results one might seek through linear Newtonian reasoning, these patterns of activity often defy causal prediction or even explication.

In chaos theory, such a phenomenon is called the butterfly effect.[36] For belligerents, it might be called a surprise. To return to the Japanese case just mentioned, no one in the American government predicted that the Nazi invasion of Poland would eventually lead to the atomic bombing of Japan. Or in more recent history that American governmental support for Manuel Noriega -- in direct opposition to communist influence in this hemisphere -- would eventually lead to *Operation Just Cause.*

And events in a war do not exist in isolation; they are dependent upon the events which preceded them. For example, policy pronouncements at the beginning of a war by government "A" establish the context for the actions that country will take during the fight. As country "B" reacts, "A" must once again analyze and develop policy options for its next move. The interactions between belligerents are time sensitive. Events during the war feed back to form the initial conditions for the remainder of the conflict.

So the doctrine of extremes describes a "total phenomenon" which clearly adheres to the fundamental tenets of a chaotic system. Events in war are sensitive to the initial conditions which dominated the beginning of the conflict. The results of actions taken by adversaries in war do not follow a linear action-reaction sequence and often lead to unexpected outcomes. The actions of belligerents over time also play a critical role in shaping conflict.

This presents military theorists with a dilemma similar to that which the researchers who first discovered chaos theory encountered: the analysis of war in two dimensions depends upon too many simplifying assumptions. The increased complexity of modern war simply cannot adequately be understood with linear reasoning. To analyze war only from a limited two dimensional perspective risks oversimplification because not every action in war leads to a clear, predictable reaction. The dynamic, limiting relationship between the dominant tendencies in the Information Age is non-linear. And confining our logic unnecessarily with constraining assumptions invites too many real world "surprises."

The significant value of chaos theory is that it goes beyond classical reasoning to provide insight into the transformed manifestations of warfare in the Information Age. Chaos theory provides greater understanding by taking the trinity beyond the two dimensions we routinely analyze in discussions of Clausewitz. Chaos adds a technological dimension to the trinity.

Given this fresh perspective, one can theoretically visualize war as suspended between magnets in a mobile. The interactions between primordial violence, the play of chance and probability, and the influence of reason describe patterns of activity in three dimensions -- not two. As theorist David Ruelle wrote in his recent book Chance and Chaos, "chaotic time evolution can take place only in a space of at least three dimensions."[37] Since war is also a chaotic time evolution, clear understanding requires a third dimension for analysis.

Clausewitz would have agreed. His original sentence in German described the task of a theory of war as maintaining itself suspended between three points of attraction.[38] But he never implied that this would happen in two dimensions. In fact, the practice of drawing the trinity as an equilateral triangle is only a method which helps us simplify his theory of war. More precisely, the word trinity itself (*Dreifaltigkeit* in German) refers to three things or beings in one, not a triangle.

The obvious problem is that the simple triangular paradigm establishes boundaries which unnecessarily confine our reasoning. The three dominant tendencies, when they behave like magnets, cannot possibly influence war in just a single plane. The points of attraction in such a system would not remain locked in stable positions relative to one another, either.

The complexity of warfare in the Information Age demands analysis of the total phenomenon of war from this updated perspective. The interactions between the dominant tendencies now happen so rapidly that they are dangerously approaching a condition of near simultaneity. As information technology transforms them, they draw ever closer to Clausewitz's theoretical limit of absolute war. To prevent such unintended consequences, we must first more completely understand the relationship between information technology and the dominant tendencies of the trinity of war.

Of course, this means that the level of sophistication which our analysis of modern war must confront is higher. But then, war in the Information Age is quite a complex phenomenon. Applying the questions posed by chaos theory to the three levels of war listed in FM 100-5, Operations[39] yields valuable insights. For the purpose of this analysis, we can begin with the tactical level, proceed to the strategic, and conclude with an in-depth examination of the cumulative effects of improved information technology at the operational level of war.

Tactical Level Chaos

As described in the opening pages of this monograph, the technology needed to process information is a key factor which helps give contemporary warfare its nearly instantaneous character. At the sharp end of the spear, information technology has the greatest influence in "the play of chance and probability within which the creative spirit is free to roam." This dominant tendency is one which concerns mainly "the commander and his army."[40]

Victorious armies are those which can either eliminate or overcome the obstacles they routinely face in the conduct of combat operations. In On War, Clausewitz described the effects of these resistant elements with an allusion to walking in water. Friction is therefore "the force that makes the apparently easy so difficult."[41] He also wrote that friction distinguishes real war from its theoretical absolute. Even though military matters appear simple on the surface, they are actually quite difficult to execute. Overcoming friction is therefore key to conducting violent, purposeful combat operations.

Effective use of information technology at the tactical level reduces friction in time and space. Orders which once took hours or even days to travel several miles are now transmitted in only seconds. Reports of enemy activity can reach distant commanders just as quickly. Armored vehicles and attack aircraft now achieve speeds and maneuverability which were impossible just a few decades ago.

Paradoxically, other forms of technology have simultaneously increased the friction caused by human fatigue in Information Age warfare. High quality thermal optics simplify target acquisition at night. Abrams tanks and Bradley fighting vehicles have achieved standards of reliability which permit operations 24 hours a day. Satellites provide blanket surveillance coverage through methodically planned reconnaissance orbits. But soldiers still face the human constraint of exhaustion during continuous operations.

At the tactical level of war, this is a critical component of modern combat. In a personal account of the Gulf War, General Sir Peter de la Billiere described British soldiers "after three nights and three days with almost no sleep" as "grey-faced." The problem was so great that their commander "started to issue all his orders in written form"[42] in order to prevent misunderstanding by sleep-deprived fighters.

To succeed, armies must think and react quickly. They must destroy their opponents rapidly before the pace of technological combat consumes them. Simply put, agile forces which react faster are better. In terms which John Boyd first coined, the belligerent army which can execute the observation-orientation-decision-action cycle (the OODA loop)[43] faster than their opponent will win.

It is interesting to note that Boyd's original intent in developing the OODA loop was to determine why American aviators in less capable F-86 aircraft were able to achieve a 10:1 kill ratio over their Korean and Chinese opponents who flew MiG-15s during the Korean war. The results of his analysis showed that conflict is a time sensitive series of observation-orientation-decision-action cycles.[44] The same can be said of warfare in the Information Age.

Improved information technology makes armies today more precisely responsive instruments of violence. Consider, for instance, the case of COL Charlie Beckwith after the crash at Desert One. While still at the rendezvous site, he had to gain the personal approval of President Carter before aborting the remainder of the mission.[45] Although this type of high level control was once constrained only to Special Operations forces, that is no longer the case. Conventional force units are also now more susceptible to precise command direction from higher levels of command than ever before.

This means that national military power can be applied with great articulation. And that a country -- not just a fighter pilot -- can try to gain an advantage over its enemy by rapidly executing the OODA loop. This is a unique characteristic of warfare in the Information Age. There are some who believe that the most effective armies are those which can exploit the advantages of information technology to react quickly. But the long term effects of such precise command direction at the tactical level are not yet clear.

This may also have important implications for force structure. What kinds of forces will be most efficient if effective command direction can be achieved directly from the National Command Authority (NCA)? Perhaps the current system of corps, divisions, brigades, battalions, companies, and platoons will be too cumbersome in the future. Information technology may permit a more simplified structure which streamlines rapid response and the OODA loop.

One of the central planning tenets in Desert Storm reflects another issue related to the concept of the OODA loop. Specifically, accurate tactical intelligence had to be relayed to "battlefield commanders so rapidly that fire power could be placed on target before the target could move sufficiently to require retargeting." The final Department of Defense report on the Gulf War to Congress even calls this tactical intelligence-targeting feedback loop "critical to success on the battlefield."[46] Clearly, American forces were able to exploit this advantage over the Iraqis.

Several communications systems to support this kind of information processing at the tactical level are already in use in many units of the U.S. Army. The Maneuver Control System (MCS), designed to coordinate maneuver control with the other four battlefield functional areas of the Army Tactical Command and Control System (ATCCS), should be completely fielded by the end of FY 94. Mobile Subscriber Equipment (MSE), a digital, automatic-switching network that allows mobile users to make calls as they would use a normal telephone, played an important role in Desert Storm. For example, "an MSE-equipped unit moving through the desert could be reached by direct dialing from the United States;" a capability which the Commander of the 1st Cavalry Division called "superb."[47]

The Intervehicular Information System (IVIS) facilitates distribution of data among M1A2 tanks. Its central operating principle is "the mutual sharing of tactical data and information within the combined arms team."[48] Each vehicle retains a common view of the battlefield, so the time necessary to transmit and receive orders is reduced. It will reduce the friction caused by time because it will automatically perform the routine tasks every armor leader must perform in combat.[49] The enhanced situational awareness IVIS provides will help units OODA faster than their opponents.

Still other concepts for information systems are in the mature stages of development. The Battalion and Below Command and Control System (B2C2) is designed to extend ATCCS to the lowest possible level of command. The Combat Vehicle Command and Control system (CVC2) will process automated digital communications over standard combat net radios.[50] The intent is to improve the speed and flexibility of the tactical decision-making cycle and thereby increase the lethality of distributed combat power.

When the data links which connect combat vehicles in individual platoons are extended to other types of vehicles and units, the result is a greatly improved ability to mass combat effects. When M1A2 tanks can rapidly exchange target information with Bradley fighting vehicles and AH64 attack helicopters, friction in time and space will be reduced even further at the tactical level. And the devastating form of war first seen in Desert Storm will dominate the battlefield.[51]

Strategic Chaos

At the strategic level, information technology affects the people and government of a nation at war most keenly. Certainly, the commander and army will also be affected, but not to the same degree. Of particular interest for this study is the increased speed with which technological interactions between these actors can now occur. The patterns of activity at this level are correspondingly more complex than at the tactical level; chaos is definitely at work.

For instance, information technology can either increase or decrease the role which primordial violence plays. It can increase the enmity one nation feels toward another and motivate the population of the first to action. Think for just a moment about the plight of the innocent people who are being overrun by Serbian aggression in the former country of Yugoslavia. Or worse yet imagine that someone you knew had been imprisoned and forced to bear Serbian children for the purposes of ethnic cleansing. The more one is reminded of the randomness of this brutality, the more appropriate retaliatory military intervention may seem.

Public information about these atrocities is now much more readily available to uninvolved persons than it was 150 years ago. Printed accounts appear in daily newspapers and CNN Headline News often begins its half-hour show with video images direct from the conflict. No such system existed during Napoleon's era or even during Vietnam. In the 18th century, any information from the front which might have been available in Paris was certain to be days old and in the barest of sketchy detail.

This means that today the population becomes more involved in its army's war. The ability to process and disseminate information to the public brings the fighting 'closer to home.' The nation whose army fights is no longer isolated from the battle. Immediacy and intimacy play increasingly important parts. One is reminded of the popular expression that Vietnam was the first conflict fought 'live' in American living rooms.

"The blind natural force"[52] of primordial violence is affected by the availability of this information. A nation's sensibilities can be offended when it is confronted with live images of mutilated victims. A nation can learn to hate more rapidly because of the availability of such information; momentum for action gathers. The magnitude of this effect is different in intensity from the one which Clausewitz described. It takes shape faster and has a greater amplitude because of the technology which makes the information readily available to the public.

The potential negative role of the media often enters into discussions of these effects at the strategic level of war. Some would even go so far as to say that there ought to be a fourth 'corner' appended to Clausewitz's theory of war. But this type of simplified reasoning keeps one's analysis locked in two dimensions. It confuses the message with the messenger and preempts hard thinking about the unpredictable nature of war.

Consider the amateur radio operator who recently told his story of war from the Bosnian Muslim town of Zepa. Even as the Serbians surrounded his village, Fadil Heljic was able to broadcast specific details about the living conditions his family had to endure. They were reduced to "eating the bark from pear trees" and dragging dead bodies down the street into a frozen common ditch. The townspeople were too exhausted to bury them.[53] And so, for a highly public moment, Heljic's experience became a metaphor for the larger issue of the war, emblematic of the suffering of all Bosnian Muslims.

No citizen in a town under siege by Napoleon's army could ever hope to communicate information in that manner. The difference is that Heljic owned the technology in a short-wave radio to disseminate his account much farther and faster. The fact that the story appeared on the front page of the Washington Post helped accelerate the movement of the information even more. The difference is one of degree and the effect the widely disseminated information can engender.

Retired LTG Frederic Brown calls this form of interaction "hyper-communications." In his recent book The U.S. Army in Transition II, he goes even further by writing that the issue is more complicated than simply dealing with the media. It involves "an awareness of the need to gain and secure the information initiative in military affairs."[54] In some important ways, this is the same as performing the OODA loop faster than an enemy force at the strategic level of war.

The flow of information is critical. Who it reaches and when it gets there can determine the events which follow at time t+1. If, as Brown suggests, a country can retain the information initiative it may stand a better chance of influencing subsequent events.

The awkward part of the equation at the strategic level is that information can simultaneously flow in both directions and along multiple dimensions. As such, technology can also decrease the tendency toward hateful retribution when policymakers use public information to calm growing enmity. Given skillful treatment, public information can therefore help keep war "subject to reason alone."[55] The uneasy balance of terror which dominated the Cold War proved to the superpowers that it was definitely in their national interest to keep war a purposeful instrument of policy. If they could not do so, and if passion subsumed reason, both the United States and the Soviet Union had much to lose.

Because of this development, modern states have learned to take advantage of information technology in their communications with one another. The White House 'hot line' comes quickly to mind. And there are even more subtle, less direct methods of technological communication. Both the U.S. and the former U.S.S.R. have used the timing and location of nuclear tests to signal either peaceful or harmful intent, for example. In his first official news conference President Clinton expressed support for the democratic reforms of Russian President Boris Yeltsin. The next day some of the pressure for impeachment from Yeltsin's own parliament was reduced.[56]

So the shape which these interactions between the dominant tendencies describe at the strategic level cannot be predicted with certainty. It is not so simple that an impulse from primordial violence causes a specific and predictable reaction by the influence of reason. A new, complicated form of technological friction also plays a role as information moves rapidly among the points of attraction. Yet one can describe the dynamic which prevails. At the strategic level, the unexpected outcomes which result from these relationships are affected by the major factor that will form the character of future wars -- information technology.

Chaos at the Operational Level of War

The interactions at the operational level of war follow a different pattern from those at either the tactical or strategic levels. U.S. Army doctrine describes this level as "the vital link between strategic aims and the tactical employment of forces."[57] This linkage can theoretically cause operational events to differ in kind from occurrences at either of the other two.

The technological reduction of certain types of friction, such as those already discussed at the tactical level, remains in effect. Information and orders move rapidly between spatially distant headquarters in huge data packets. Army and corps commanders communicate with one another instantaneously via satellites and mobile telephone systems. Reports of enemy activity are flashed from Joint Surveillance Target Attack Radar System (JSTARS) sensors to units which respond both day and night.

But linking tactical engagements and battles to achieve strategic objectives makes the operational level of war substantially different. In effect, operational commanders charged with this responsibility create a demand for their units to operate on an uninterrupted basis. Certainly, modern military equipment can function for extended periods. But soldiers cannot easily do so. Since battles must be connected in logical sequence to achieve success at the operational level, high-consumption fatigue will certainly be introduced.

This applies to all committed combat units and the units which support them. In fact, perhaps the must excruciating kinds of surprise can be found in logistical shortages. High intensity operations exact a great cost in gallons of fuel and short tons of ammunition. And the soldiers who must move those mountains of supply are just as susceptible to exhaustion as the warriors. Although logistical friction played an important role in Clausewitz's era, in relative terms it is now far more important than ever before.

Primordial violence and policy also interject their influence from the strategic level into the operational arena. The dividing line between these two levels of war is indistinct. Information technology makes the distinction even less clear; information now flows directly between the two in near real time. In effect this development produces a changed reality at the operational level. Unintended outcomes are the result.

The assault to secure Colon during the American invasion of Panama is a case in point. The order to secure the city was given on Friday, 22 December 1989. But the timing of the end of the operation was determined by the influence of information technology; the task force commander learned of his new deadline by watching Ted Koppel's *Nightline* show later that evening.

Colonel Keith Kellogg had the opportunity to see General Maxwell Thurman live on the program while his soldiers were still in the process of establishing security. But after Thurman said on live television that U.S. soldiers "now control the city of Colon," Kellogg's time table was greatly compressed. He immediately radioed the commander of the 4th Battalion, 17th Infantry and said "whatever you do, get me Colon by six in the morning and for God's sake, don't get in a firefight as you do it, because General Thurman just told the entire world we own the city of Colon."[58] At the very minimum, such guidance puts great pressure on the commander of a light infantry battalion clearing a large urban danger area. It also severely limits the options available to the tactical force.

In recent operations in Somalia, the Marines were also directly affected by the unexpected influence of information technology. The initial concept of the operation was comprised of four phases.[59] In the first phase, the Marines had to secure and develop the port of Mogadishu. They then wanted to extend their security operations to establish safe routes for relief workers to major interior food distribution centers in Phase II. Once that was accomplished, the plan was then to expand the security effort in Phase III to include smaller outlying towns affected by the violence of the Somali civil war. The final phase was to be a relief in place of U.S. forces by a United Nations command.

But public information from some of those smaller towns forced a rapid change in the military plan. Relief workers and journalists who ventured out from the already secure routes reported that in some of the Phase III towns no Somali bandits (technicals) threatened relief operations. There was, therefore, no legitimate security reason to delay the delivery of food to the starving people in those towns. Once this knowledge was widely disseminated, national pressure to accelerate from Phase II to Phase III mounted.

The Marines modified their security operation accordingly. The fact that public information from the tactical level was transmitted directly to the national body politic motivated the military force to act more rapidly than originally planned. The result was an initially unexpected outcome which linked tactical actions to strategic objectives.

The dynamic created by information technology at the operational level is therefore quite intricate. Influences from both strategic and tactical events overlap. Linear analysis alone cannot adequately account for the shape of these interactions or the resultant effects which are produced by them.

Chaos at the Safwan Airfield & Road Junction

A timely case study of the cumulative effects of information technology at the operational level can be found near the end of Desert Storm. From the outset of that conflict in August 1990, President George Bush repeatedly stated that neither the American people nor the international community had any quarrel with the people of Iraq. By so doing, President Bush established the political context for future American military actions. In effect, he made the war a presidential one with his statement to the press that the aggression against Kuwait would not stand.[60]

But at the same time, President Bush knew that both domestic and international support for a war effort had to be mobilized. To accomplish this, he focused American public opinion on the political parameters which he established: Iraq's aggression had to be reversed. Bush shaped public sentiment in favor of the military actions which he believed necessary. This was a critical component of his Gulf War policy. He politically constrained the influence of public opinion to the objectives he established.

This is not to say that public opinion played an unimportant role. It was simply transmitted directly into military objectives which remained subordinate to command direction. Reports of brutality by the Iraqis who invaded Kuwait aided this process when they caused a strong negative reaction in both domestic and international public opinion. The global community rapidly closed ranks in United Nations Resolution 678[61] and authorized the use of all means necessary to force Iraq out of Kuwait. This unanimity is important, because it is rare in contemporary international politics.

The combination of these effects meant that the war remained an instrument of policy subject to reason alone. The President's publicly stated political objectives had an especially strong affect on the conduct of the war. In relative terms, the "magnet" of his policy was more powerful than primordial passion. The military goals for the theater, which flowed directly from American national policy, dictated the military means employed by U.S. forces. The conduct of the war itself matched the political ends established by the National Command Authority.

The military means to attain those ends were clear: purposeful application of all available combat power. The aggressiveness of U.S. soldiers in combat was not caused by mistakes of kindness; one obviously has to feel a certain amount of enmity to kill even in combat. But the determination felt by American forces in Desert Storm remained directed toward the objectives expressed by President Bush. Like a laser beam, the violence was pointed directly at a well defined and attackable object: the Iraqi army in Kuwait.

The action in question took place on 27 and 28 February, just before the end of the ground war. It centered on a road junction and airfield north of the town of Safwan in southeastern Iraq. The road junction sat astride the major Iraqi lines of retreat. As units of the Republican Guard Forces Command (RGFC) tried to escape north beyond the Euphrates River, they had to pass through the road junction. The airfield was a military landing strip about two miles from the road intersection, near a mountain which could have been a storage site for Scud missiles.[62]

Although the cease fire was to begin only a few hours later, General Norman Schwartzkopf's intent at that point during the battle was to destroy as much enemy equipment as possible during the fighting which remained. To do this, he ordered the VII Corps to "... attack in zone to destroy enemy armored vehicles and to seize the road junction vic. QU 622368."[63] The purpose of Schwartzkopf's instruction was to immediately block the road and destroy or capture any enemy equipment which tried to leave the theater. He felt at the time that "the whole sector was crucial to our ability to block the escape of Iraqi heavy equipment from Kuwait and root out any remaining Scud storage bunkers."[64]

Schwartzkopf's orders were not clearly understood by the commanders of the VII Corps and the 1st Infantry Division (1st ID(M)).[65] Given the location of the road intersection and airfield relative to the forces on the ground, the 1st ID(M) was the closest unit which could quickly execute the attack. Early on the morning of the 28th a message to that effect was sent to the VII Corps.[66] But the order was never completely understood by the Division. They remained oriented to the east, in the direction they had been attacking all day. As a result, no force initially occupied the terrain objective Schwartzkopf had designated.

The play of chance and probability helped cause this misunderstanding at Safwan. In fact, its effects permeated the actions of all the major participants, creating space "within which the creative spirit [was] free to roam."[67] For example, after almost 100 hours of combat operations, fatigue among the combatants was understandably widespread. At the sharp end of the spear, the 1st Infantry Division and its leaders had begun their attack through the 'Saddam line' on 24 February and operated continuously until this point in the action.

Moreover, much of the confusion was caused when orders were transmitted directly to tired leaders by voice media instead of in writing. The use of voice was necessary due to the pace of the operation. General Fred Franks, for example, received his instructions from the ARCENT commander by phone.[68] In the case of the 1st Infantry Division, the Main Command Post (CP) was unable to keep up with the fighting units[69], so Major General Tom Rhame commanded from a tank near his lead brigades. All of his communications with VII Corps were relayed, which added additional filters to the coordination process.

In retrospect, the fact that Schwartzkopf's intent was not clearly understood by all his subordinate commanders seems reasonable to expect. Although they had been attacking force oriented objectives for several days, Safwan was strictly a terrain objective. None of the units which misunderstood the order were routinely assigned to Central Command, either, so the standard operating methods which grow out of habitual associations was absent.

Additionally, Schwartzkopf had already given his victorious "Mother of All Briefings" on the night of the 27th. Many units interpreted that televised CENTCOM briefing as the preparatory command to halt offensive operations.[70] In the field, the forces were emotionally and intellectually ready to stop fighting and begin protecting their forces.

But no matter how refined the military technology, it still takes a certain amount of time to halt units as large as those under consideration. Even our most powerful and nimble aircraft carriers require time and space to stop moving or change direction on the open seas. The same is true of armored corps and divisions: their turning radius in time and distance is quite large.

Because of the combination of these factors, there was a significant difference in perceptions at each level of command about the situation at Safwan. As the potential end of combat operations approached, General Schwartzopf held a different perception about ground reality from that which was true at the corps and division level. When he learned the truth later that day, he "felt as though [he'd] been punched in the gut."[71]

As a result of this chain of events, the Army Component Commander of the U.S. Central Command, the VII Corps Commander, and the Commander of the 1st Infantry Division each had to submit to General Schwartzkopf in writing a defense of their actions regarding the Safwan airfield/road junction complex.[72] Certainly no one could have initially anticipated this unexpected outcome for the ground war. In fact, by almost every measure, the military operation had been an outstanding success up until that point.

The difference at Safwan was that precise command direction from the strategic level caused policy to exert a greater influence at the operational level far faster than was ever previously the case. Schwartzkopf's specific interest in the Safwan area was caused by the unsuitability of the Jalibah air base as a potential location for the cease fire talks.[73] When a change became necessary, Safwan was chosen as the site. But once this information was relayed to the Chairman of the Joint Chiefs of Staff (CJCS), it gathered an inertia all its own.

The CJCS had already told the President that the talks would take place at Safwan.[74] It was only later that Schwartzkopf learned no one had actually seized the specified terrain objectives at that location. But since the information had already been communicated to the White House over a secure telephone, neither the CJCS nor General Schwartzkopf were willing to change the location yet again.

In other words, the fact that the information had already been relayed to key decisionmakers in the White House was critical. The events which took place shortly thereafter were a direct result of where and when that information reached the focal point of political control. President Bush and General Colin Powell shared a common view of ground truth with General Schwartzkopf. Generals Frank and Rhame saw the situation quite differently. Had the information arrived in the White House only a short time later, or not been relayed to the President at all, the story of Safwan would perhaps have ended differently.

But within an hour of Schwartzkopf's briefing, General Powell called Schwartzkopf from the Oval Office on a secure phone.[75] One of the extensions was kept in a drawer of the President's desk. Information technology provided a capability which Clausewitz never imagined possible; that phone connected the political leader and his principal advisors directly to the operational commander. Policy could therefore exert an immediate influence on events at the operational level of war. Because of the information technology which supported these developments, the 'magnetic attraction' of policy was exceptionally strong.

The effect of such precise command direction from Washington was a compression of the layers down to the 1st Infantry Division. Even though it differed from reality on the ground, the President's perceived 'truth' skipped echelons down to the soldiers who then had to go secure the Safwan complex. Fortunately, the Iraqi forces which had moved into the area eventually left without a fight.

Conclusion

In retrospect, what happened in and around Safwan seems to have been a quite regrettable incident which need not have occurred. Upon closer inspection, however, we can see that it was a product of the cumulative effect of information technology at the operational level of war. As such, it was fundamentally a manifestation of Information Age warfare.

Although one's first impression might be that technologically refined means of purposefully manipulating and using information rapidly should lead to less friction, just the opposite result can obtain. Another, more subtle dynamic is also at work. That dynamic is a product of the dominant feature of this age: information technology. Paradoxically, the cumulative effect of information technology at the operational level yields a new, unintended type of friction.

The Clausewitzian theory of war is expansible enough to provide a clear perspective on what transpired at Safwan, and why. The three dimensions of the trinity shed light onto why "an obscure road junction in southeastern Iraq"[76] became so important only after the main offensive operation was ended. All three Clausewitzian dominant tendencies were at work; the outcome they produced was highly unexpected. The relationship between public opinion, national policy and chance produced a changed manifestation of Information Age war at Safwan.

The personal computer (PC) serves as a useful paradigm for understanding this phenomenon. A modern PC can process complex information far faster than its human operator can possibly input data. The limiting factor is the human being who sits in front of the machine. The tempo of the data that goes into the PC determines the speed with which information appears on the monitor. If scientists could ever design a more capable input device, computing speeds would transform.

Of course, such an invention will take time and energy to develop. It may also not have adequate reasoning skills to duplicate a human's sensibilities. But the technological momentum in that direction is unambiguous. Faster data manipulation would certainly be possible. A brand new form of computing would be the result. The role of the PC in everyday life would be transformed.

The same is true of national command direction in contemporary war. Technology can process information and orders more rapidly than the humans who operate communications devices and the fatigued commanders who lead fighting units. When the influence of national policy technologically outpaces the reaction speed of 'large turning radius' tactical units, new friction at the operational level of war will cause unexpected outcomes.

Perhaps new friction will become an advantage if we can anticipate and exploit its effects faster than our adversaries. But it is almost certain that increasing amounts of highly articulated command direction will again cause future Safwan-like misunderstandings. This has important implications for the U.S. Army in the field. Having just set our doctrine for the near term future, we are poised to incorporate this transformation into the way our army fights. The final draft of FM 100-5 is flexible enough to adapt to these changes just as Clausewitzian theory can.[77]

As an Army, though, we must also turn our attention to the force structure issues which follow from this analysis. New friction indicates that radical changes will occur in the size and type of forces we employ. Those units which respond best to precise command direction will be preferred: smaller units are less likely to be affected by the complicated dynamic of information technology than larger ones. For example, agile brigade size units can be more responsive to command direction than divisions. The trend is obvious. That which can be controlled from afar will be.

Additionally, the chain of command which we now employ is over two centuries old. It dates back to Napoleon's era when armies changed from unitary actors to more articulated forces which could respond rapidly on the battlefield. To return briefly to Figure 1, this period would fall somewhere between the Mytilenian Debate and World War I Message circles.

Those eighteenth century changes gave shape and form to what had once only been matters of speculation about military practices in combat. This monograph represents a new form of speculation about the future relationship between theory, doctrine, force composition, and structure of command. The issue is how this speculation might eventually be resolved on the battlefield.

It is a commonplace today that technology is changing the way our army fights. But that description does not go far enough. The cumulative effects of information technology at the operational level of war will soon transform the operational art. The longer term implications of this trend are not yet clear. Certainly, it represents change -- but can it correctly be called military progress?

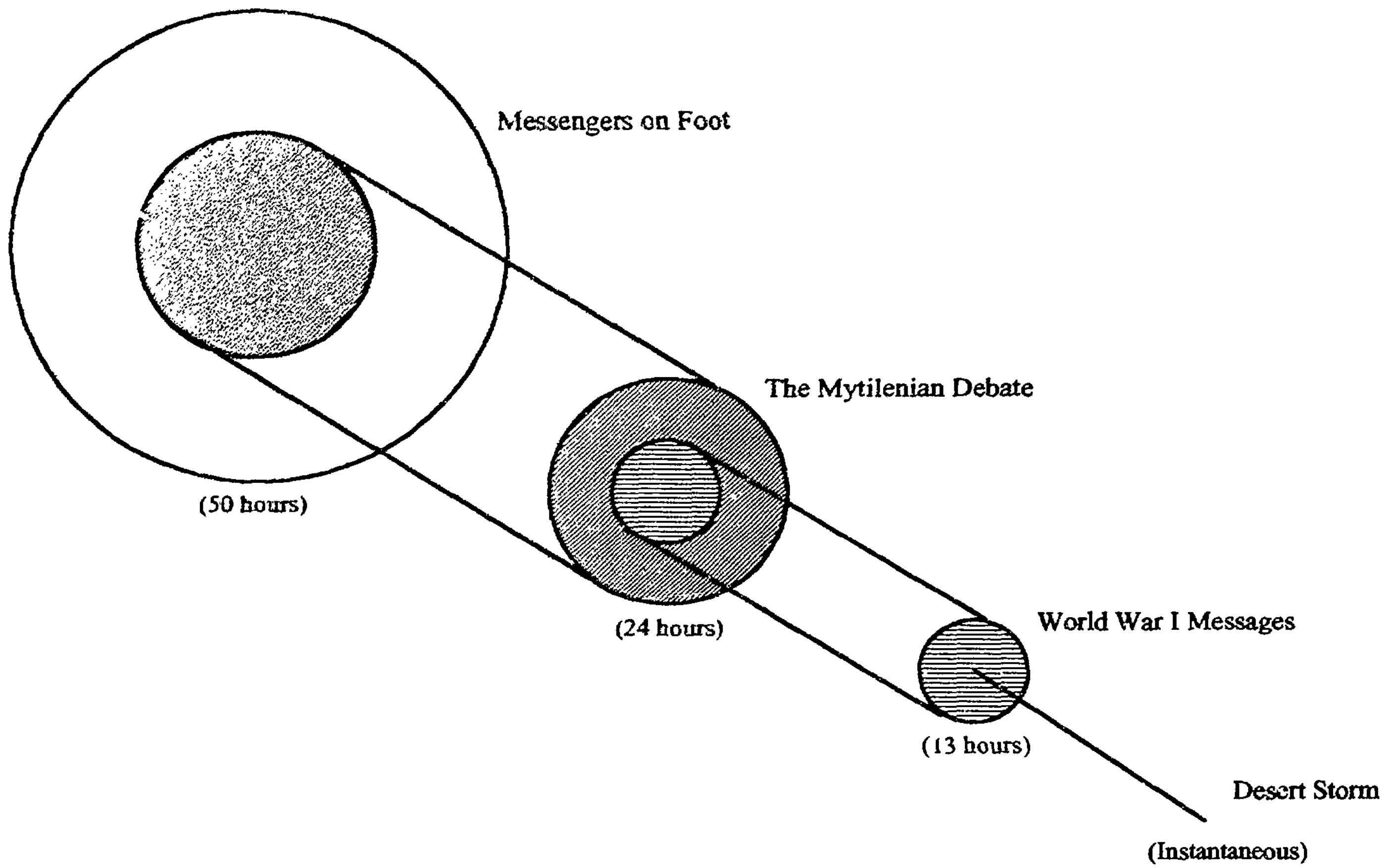

Figure 1: Time Compression of Policy Influence
in Military Operations

Explanatory Notes to Figure 1

Just after the Mytilenean revolt in 428-427 B.C., the Athenians dispatched a trireme to Paches with instructions to "put the Mytilenians to death immediately." But the next day they debated the cruelty of the decision to destroy the entire population of Mytilene due to the actions of approximately 1,000 people. After their argument, the Athenians concluded they had followed their primordial instincts too rapidly and changed their initial decision. They then decided to immediately send another messenger in order to reassert the influence of reason on their earlier actions. The second trireme was sent out "in all haste" and rowed continually in the attempt to catch up. (For the exciting end of the story, see Thucydides, The History of the Peloponnesian War, (New York, New York: Penguin Books, 1954), pp. 194-223).

The Mytilenean case represents a clear example of an attempt by one government to exert political control over spatially distant military action. For simplicity, each successive circle in the diagram represents the approximate amount of time needed to transmit a secure message a distance of 200 miles -- the distance from Athens to Mytilene. The data used in the figure was not scientifically derived but supports the analysis in this monograph. The purpose of this simple diagram is to portray the acceleration over time of the ability of political systems to exert the control of reason from afar. The information is portrayed in relative terms, because it is the rate at which this change in communications speed has taken place which is of interest for the phenomenon under consideration.

Human capacity to deliver a message on foot is largely unchanged from ancient times. The notional messenger system shown in the diagram sustained a rate of march of approximately four miles per hour for the entire distance; an optimistic rate given the distance to be travelled. The Field Service Pocket Book shows that mounted U.S. Army messengers could move 440 yds./minute in 1917. So the World War I messages in the figure could be delivered in about 13 hours and 20 minutes. The Desert Storm example obviously speaks for itself.

Clearly, the time needed to exert political control on far removed military operations has been compressed over the years portrayed in the diagram. As the technological capacity to influence military operations through communications has rapidly improved, a new dynamic in Information Age warfare has been created.

ENDNOTES

[1] Don Oberdorfer, The Turn: From the Cold War to a New Era (New York: New York: Poseidon Press, 1991), pg. 223.

[2] Ibid.

[3] Ibid.

[4] Mikhail Gorbachev, Perestroika: New Thinking for Our Country and the World (New York, New York: Harper & Row, Publishers, 1987), pg. 93.

[5] Anders Aslund, Gorbachev's Struggle for Economic Reform (Ithaca, New York: Cornell University Press, 1989), pg. 16.

[6] Joseph Finkelstein, Windows on a New World: The Third Industrial Revolution (New York, New York: Greenwood Press, 1989), pg. 171.

[7] Gorbachev, pg. 135.

[8] R.A. Powell, "Microelectronics," in Joseph Finkelstein, Windows on a New World: The Third Industrial Revolution (New York, New York: Greenwood Press, 1989), pg. 2.

[9] J.E. Burke, "Materials and Modern Technology," in Joseph Finkelstein, Windows on a New World: The Third Industrial Revolution (New York, New York: Greenwood Press, 1989), pg. 63.

[10] United States Department of Commerce, Report of the National Critical Technologies Panel (Arlington, Virginia: U.S. Government Printing Office, March 1991), pg. 63. See also Truxal, John G, The Age of Electronic Messages (Cambridge, Massachusetts: MIT Press, 1990), pg. 473. Truxal maintains that a single cable can carry over 40,000 conversations; a staggering figure.

[11] Powell, General Colin, "Information-Age Warriors," BYTE (Volume 17, Number 7, July 1992), pg. 370.

[12] Carl von Clausewitz, On War, edited and translated by Michael Howard and Peter Paret (Princeton, New Jersey: Princeton University Press, 1976), pg. 580.

[13] Antoine Henri Jomini, Summary of the Art of War, edited by Brig. Gen. J.D. Hittle in Roots of Strategy, Book 2 (Harrisburg, Pennsylvania: Stackpole Books, 1987), pg. 452.

[14] Clausewitz, pg. 580.

[15] The expression that war has *moved* is an extension of Clausewitz's description of war as a "true chameleon" (pg. 89) that adapts to the dominant features of a specific era in history. Over time, significant improvements in military technology produce changes in the manifestations of war. Asymmetries result when one force effectively employs new technologies which their adversary cannot match. This technological dynamic creates changes which make warfighting methods different from previous ones. Examples from history include the employment of gunpowder, cannons, rifled weapons, iron clad ships, machine guns, long range artillery pieces, chemical artillery shells, tanks, airplanes, submarines, rockets, aircraft carriers, biological munitions, and nuclear weapons. In the future, we may well witness the deployment of extreme light and noise producing weapons and perhaps grid systems of sensor controlled smart weapons. Therefore, war *moves* through history in concert with this process of technological change.

[16] Ibid, pg. 89.

[17] Ibid, pg. 87.

[18] Ibid, pg. 88.

[19] Ibid, pg. 77.

[20] Ibid.

[21] Ibid, pg. 81.

[22] Ibid, pg. 78.

[23] Perry M. Smith, How CNN Fought the War: A View From the Inside (New York, New York: Carol Publishing Group, 1991), pg. 133.

[24] U.S. Army, Field Manual 100-5 -- Operations (Final Draft) (19 January 1993), pg. 3-15.

[25] James Gleick, Chaos: Making a New Science (New York, New York: Viking Press, 1987), pg. 6.

[26] Ian Stewart, "Does Chaos Rule the Cosmos?", Discover (Volume 13, Number 11, November 1992), pg. 58.

[27] David K. Campbell, "Nonlinear Science -- From Paradigms to Practicalities," in Los Alamos Science Number 15 (Special Issue 1987), pg. 224.

[28] Stewart, "Does Chaos Rule the Cosmos?", pg. 58.

[29] Gleick, pg. 306.

[30] Alan D. Beyerchen, "Nonlinear Science and the Unfolding of a New Intellectual Vision," Papers in Comparative Studies, Volume 6 (Ohio State University: Center for Comparative Studies in the Humanities, 1989), pg. 25.

[31] For a mathematical examination of simple system equations which describes the mechanistic view of the world as "wrong in the large," see Robert Shaw, "Strange Attractors, Chaotic Behavior, and Information Flow," in Zeitschrift fuer Naturforschung Volume 36a (1981): 80-112.

[32] For a straightforward explanation of both proportionality and additivity, see Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," International Security (Volume 17, Number 3, Winter 1992/93), pg. 62. For a more thorough treatment of the mathematical components of nonlinearity, see also Campbell, "Nonlinear Science -- From Paradigms to Practicalities," pp. 218-262.

[33] Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," pg. 65.

[34] Steven R. Mann, "Chaos Theory and Strategic Thought," Parameters (Volume XXII, Number 3, Autumn 1992), pg. 58.

[35] John W. Dower, War Without Mercy (New York, New York: Pantheon Books, 1986), pp. 53-54.

[36] Although it causes complex outcomes, the butterfly effect is simple to describe: "very tiny changes become amplified to produce major changes in the observed motion." The name is drawn from the study of weather. When a butterfly flaps its wings in Kansas it can change the weather pattern the following month in Europe. See Stewart. "Does Chaos Rule the Cosmos?", pg. 63.

[37] David Ruelle, Chance and Chaos (Princeton, New Jersey: Princeton University Press, 1991), pg. 81.

[38] "Die Aufgabe ist also, dass sich die Theorie zwischen diesen drei Tendenzen wie zwischen drei Anziehungspunkten schwebend erhalte." Literally, "The task is therefore, that the theory maintain itself suspended between these three tendencies as between three points of attraction." See General von Clausewitz, Vom Kriege (Berlin, Germany: B. Behr's Verlag, 1915), pg. 21.

[39] U.S. Army, Field Manual 100-5 -- Operations, pg. 1-5.

[40] Clausewitz, pg. 89.

[41] Ibid, pg. 121.

[42] General Sir Peter de la Billiere, Storm Command: A Personal Account of the Gulf War (New York, New York: Harper Collins Publishers, 1992), pp. 297-298.

[43] Retired fighter pilot John Boyd first described the OODA loop in a briefing called "Patterns of Conflict" and in unpublished notes titled "A Discourse on Winning and Losing." Descriptive explanations can also be found in William S. Lind, Maneuver Warfare Handbook (Boulder, Colorado: Westview Press, 1985), pp. 4-6 and in the explanatory notes of the Marine Corps' doctrinal manual FMFM 1, Warfighting (Washington, D.C.: Headquarters U.S. Marine Corps, 1989), pg. 84.

[44] Lind, pp. 4-5.

[45] See Paul B. Ryan, The Iranian Rescue Mission: Why It Failed (Annapolis, Maryland: Naval Institute Press, 1985), pp. 84-85, James H. Kyle, The Guts To Try (New York, New York: Orion Books, 1990), pg. 293, and Charlie A. Beckwith, Delta Force (New York, New York: Harcourt Brace Jovanovich, 1983).

[46] United States Department of Defense, Conduct of the Persian Gulf War Pursuant to Title V of the Persian Gulf Conflict Supplemental Authorization and Personnel Benefits Act of 1991 (Washington, D.C.: U.S. Government Printing Office, April 1992), pp. 229-230.

[47] Ibid, pg. 566.

[48] CPT James B. Henderson, "IVIS Operational Concept," Directorate of Combat Developments Report (Fort Knox, Kentucky: U.S. Army Armor Center, 1992), pg. 6.

[49] The foreunner of IVIS was a system called the Battlefield Management System (BMS). In a 1987 thesis at the Naval Postgraduate School, Peter Polk and Gary Lee analyzed the impact which a tactical automation system would have in combat situations. Polk and Lee analyzed audio tapes of units training at the National Training Center (NTC). By establishing the digital specifications of a notional BMS and injecting those capabilities into the recorded scenario, they realized substantial time savings in each combat mission. See Peter B. Polk and Gary A. Lee, "Battlefield Management System: Data Requirements to Support Passage of Company Level Tactical Information" (Monterey, California: Naval Postgraduate School, March 1987).

[50] For a more detailed examination of the technical capabilities of these communications technologies at the tactical level of war see Stoner, "Can We Talk? Transformational Leadership and Communications Technology at the Tactical Level of War" (Fort Leavenworth, Kansas: School of Advanced Military Studies

Monograph, U.S. Army Command and General Staff College, December 1992), pp. 24-32.

[51] The official estimate of Iraqi tanks, armored personnel carriers, and artillery pieces captured or destroyed during Desert Storm is 8,214. The average number of vehicles destroyed was therefore almost 1.5 per minute of combat; over 14 enemy soldiers surrendered to CENTCOM forces during the same average minute. See United States Department of Defense, Conduct of the Persian Gulf War Pursuant to Title V of the Persian Gulf Conflict Supplemental Authorization and Personnel Benefits Act of 1991, pg. 294.

[52] Clausewitz, pg. 89.

[53] Peter Maass, "A Cry for Help From a Frozen Hell," The Washington Post 13 January 1993, pp. A-1 & A-16.

[54] Frederic J. Brown, The U.S. Army in Transition II: Landpower in the Information Age (New York, New York: Brassey's, Inc., 1993), pg. 11.

[55] Clausewitz, pg. 89.

[56] President Clinton approached the press conference fully aware that aid to Russia would be the main topic of questions he would have to address. The consistent theme which he presented was that Washington was firmly behind Yeltsin as the leader of democratic political reform. Support from the United States was offered through economic engagement with funds which could be rapidly spent by Yeltsin's government. See Bruce W. Nelan, "A Friend in Need," TIME, 5 April 1993, pp. 22-27.

[57] Field Manual 100-5 -- Operations (Final Draft), pg. 5-2.

[58] Thomas Donnelly, Margaret Roth and Caleb Baker, Operation Just Cause: The Storming of Panama (New York, New York: Lexington Books, 1991), pp. 291-305.

[59] Command Briefing by the United States Central Command (Tampa, Florida: MacDill Air Force Base, 8 January 1993), pg. 6. The specific information about the phases of the operation was taken from that briefing.

[60] Conduct of the Persian Gulf War Pursuant to Title V of the Persian Gulf Conflict Supplemental Authorization and Personnel Benefits Act of 1991, pg. 31.

[61] Ibid, pg. 319.

[62] General H. Norman Schwartzkopf, It Doesn't Take a Hero (New York, New York: Bantam Books, 1992), pp. 474-475.

[63] COL Richard Swain, unpublished manuscript on the 1990-1991 Persian Gulf War (Fort Leavenworth, Kansas: U.S. Army Command and General Staff College), pp. 394-395.

[64] Schwartzkopf, pg. 475.

[65] At that time, the 1st ID(M) was under the operational control of the VII Corps.

[66] Swain, pp. 391-396.

[67] Clausewitz, pg. 89.

[68] Swain, pg. 395.

[69] Ibid, pg. 391.

[70] Ibid, pg. 392.

[71] Schwartzkopf, pg. 475.

[72] Ibid, pg. 420.

[73] The XVIII Corps commander had reported through the Third Army commander that unexploded ordnance made the area unsafe for the talks. See Schwartzkopf, pg. 474.

[74] Swain, pg. 420.

[75] Ibid pg. 392.

[76] Swain, pp. 414-415.

[77] See, for example, the prologue to the Final Draft which directly addresses this issue and the role which doctrine plays in resolving it.

BIBLIOGRAPHY

Books

Allard, Kenneth C. Command, Control and the Common Defense. New Haven, Connecticut: Yale University Press, 1990.

Allmayer-Beck, Johann Christoph. Clausewitz, Jomini, Erzherzog Carl: Eine geistige Trilogie des 19. Jahrhunderts und ihre Bedeutung fuer die Gegenwart. Wien, Austria: Oesterreichishcer Bundesverlag, 1988.

Aron, Raymond, translated by Christine Baker and Norman Stone. Clausewitz: Philosopher of War. Englewood-Cliffs, New Jersey: Prentice-Hall, Inc., 1985.

Aslund, Anders. Gorbachev's Struggle for Economic Reform. Ithaca, New York: Cornell University Press, 1989.

Beckwith, Charlie A. Delta Force. New York, New York: Harcourt Brace Jovanovich, 1983.

Bellamy, Chris. The Future of Land Warfare. New York, New York: St. Martin's Press, 1987.

Blackwell, James. Thunder in the Desert: The Strategy and Tactics of the Persian Gulf War. New York, New York: Bantam Books, 1991.

Brown, Frederic J. The U.S. Army in Transition II: Landpower in the Information Age. New York, New York: Brassey's (US), Inc., 1993.

Cimbala, Stephen J. Clausewitz and Escalation: Classical Perspective on Nuclear Strategy. Portland, Oregon: Frank Cass & Co., Ltd., 1991.

Clausewitz, Carl von. Vom Kriege. Berlin, Germany: B. Behr's Verlag, 1915.

Clausewitz, Carl von, edited and translated by Michael Howard and Peter Paret. On War. Princeton, New Jersey: Princeton University Press, 1976.

de la Billiere, General Sir Peter. Storm Command: A Personal Account of the Gulf War. New York, New York: Harper Collins Publishers, 1992.

Donnelly, Thomas, Margaret Roth and Caleb Baker. Operation Just Cause: The Storming of Panama. New York, New York: Lexington Books, 1991.

Dower, John W. War Without Mercy. New York, New York: Pantheon Books, 1986.

Finkelstein, Joseph, editor. Windows on a New World. New York, New York: Greenwood Press, 1989.

Forester, Tom. High-Tech Society: The Story of the Information Technology Revolution. Cambridge, Massachusetts: The MIT Press, 1987.

Gaddis, John Lewis. The United States and the End of the Cold War: Implications, Reconsiderations, Provocations. New York, New York: Oxford University Press, 1992.

Gallie, W.B. Philosophers of Peace and War. New York, New York: Cambridge University Press, 1978.

Gat, Azar. The Origins of Military Thought: From the Enlightenment to Clausewitz. New York, New York: The Oxford University Press, 1989.

Gleick, James. Chaos: Making a New Science. New York, New York: Viking Press, 1987.

Gorbachev, Mikhail. Perestroika: New Thinking for Our Country and the World. New York, New York: Harper & Row, Publishers, 1987.
Handel, Michael I. Sun Tzu and Clausewitz Compared. Carlisle Barracks, Pennsylvania: Strategic Studies Institute, 1991.
Harfield, Alan. Pigeon to Packhorse: The Illustrated Story of Animals in Army Communications. Chippenham, England: Picton Publishing, 1989.
Howard, Michael. Clausewitz. New York, New York: Oxford University Press, 1983.
Kyle, James H. The Guts To Try. New York, New York: Orion Books, 1990.
Leinveber, Generalmajor a. D. Mit Clausewitz durch die Raetsel und Fragen, Irrungen und Wirrungen des Weltkrieges. Berlin, Germany: B. Behrs Verlag, 1926.
Leonard, Roger Ashley. A Short Guide to Clausewitz On War. New York, New York: G.P. Putnam's Sons, 1967.
Lind, William S. Maneuver Warfare Handbook. Boulder, Colorado: Westview Press, 1985.
MacDonald, Brian, editor. War in the Eighties: Men Against High Tech. Toronto, Ontario: Canadian Institute of Strategic Studies, 1983.
Marshall, S.L.A. Men Against Fire. Gloucester, Mass: Peter Smith, 1978.
Marwedel, Ulrich. Carl von Clausewitz: Persoenlichkeit und Wirkungsgeschichte seines Werkes bis 1918. Boppard am Rhein, Germany: Harald Boldt Verlag, 1978.
Murray, Major Stewart L. The Reality of War. London, England: Hugh Rees, Ltd., 1909.
Oberdorfer, Don. The Turn: From the Cold War to a New Era. New York, New York: Poseidon Press, 1991.
Osborne, Adam. The Next Industrial Revolution. Berkeley, California: McGraw-Hill, Inc., 1979.
Paret, Peter. Clausewitz and the State. Princeton, New Jersey: Princeton University Press, 1985.
Pearton, Maurice. Diplomacy, War and Technology Since 1930. Lawrence, Kansas: University Press of Kansas, 1984.
Prigogine, Ilya and Isabelle Stengers. Order Out of Chaos: Man's New Dialogue With Nature. New York, New York: Bantam Books, 1984.
Przemieniecki, J.S., editor. Critical Technologies for National Defense. Washington, D.C.: American Institute of Aeronautics and Astronautics, 1991.
Rost, Joseph C. Leadership for the Twenty-First Century. New York, New York: Praeger Books, 1991.
Ruelle, David. Chance and Chaos Princeton, New Jersey: Princeton University Press, 1991.
Ryan, Paul B. The Iranian Rescue Mission: Why It Failed. Annapolis, Maryland: Naval Institute Press, 1985.
Schering, Walther Malmsten. Die Kriegsphilosphie von Clausewitz. Hamburg, Germany: Hanseatische Verlagsanstalt, 1935.
Schwarzkopf, General H. Norman. It Doesn't Take A Hero. New York, New York: Bantam Books, 1992.

Szyliowicz, Joseph S., editor. Technology and International Affairs. New York, New York: Praeger Publishers, 1981.

Thucydides, translated by Rex Warner. History of the Peloponnesian War. New York, New York: Penguin Books, 1972.

Tufte, Edward R. The Visual Display of Quantitative Information. Cheshire, Connecticut: Graphics Press, 1983.

Truxal, John G. The Age of Electronic Messages. Cambridge, Massachusetts: MIT Press, 1990.

van Creveld, Martin. Command in War. Cambridge, Massachusetts: Harvard University Press, 1985.

Woods, David L. A History of Tactical Communications Techniques. New York, New York: Arno Press, 1974.

Woodward, Kathleen, editor. The Myths of Information: Technology and Postindustrial Culture. Madison, Wisconsin: Coda Press, Inc., 1980.

Articles and Papers

Aubin, Stephen. "The Media's Impact on the Battlefield." Strategic Review Volume XX, Number 1 (Winter 1992): 55-61.

Bak, Per and Kan Chen. "Self Organized Criticality." Scientific American Volume 264, Number 1 (January 1991): 46-53.

Benzoni, Joseph F. and David T. Orletsky. "Military Applications of Fiber Optics Technology." A Rand Corporation Study (May 1989).

Beyerchen, Alan. "Nonlinear Science and the Unfolding of a New Intellectual Vision." Papers in Comparative Studies Volume 6 (1988-1989): 25-49.

Beyerchen, Alan. "Clausewitz, Nonlinearity, and the Unpredictability of War." International Security Volume 17, Number 3 (Winter 1992/93): 59-90.

Byrne, John A. with Richard Brandt and Otis Port. "The Virtual Corporation." BusinessWeek Number 3304 (February 8, 1993): 98-103.

Campbell, David K. "Nonlinear Science: From Paradigms to Practicalities." Los Alamos Science Number 15 (Special Issue 1987): 218-262.

Dubik, LTC James M. "Military Force: Preparing for the Future." Military Review (March 1992): 77-83.

Epstein, Joshua M. "The 3:1 Rule, the Adaptive Dynamic Model, and the Future of Security Studies." International Security Volume 13, Number 4 (Spring 1989): 90-127.

Giboney, MAJ Thomas B. "Commander's Control From Information Chaos." Military Review (November 1991): 34-38.

Goodman, Ann. "Are Markets as Messy as They Look?" Wall Street & Technology Volume 9, Issue 9 (May 1992): 23-29.

Griffin, Gary B. The Directed Telescope: A Traditional Element of Effective Command. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1991.

Henderson, CPT James B. "IVIS Operational Concept." Directorate of Combat Developments Report. Fort Knox, Kentucky: U.S. Army Armor Center, 1992.

Howard, Michael. "Winning the Peace: How Both Kennan and Gorbachev Were Right." Times Literary Supplement, Number 4684 (January 8, 1993): pp. 8-9.

Karch, Lawrence G. "Chaos Theory and the Corps." The Marine Corps Gazette Volume 77, Number 4 (April 1993): 57-58.

Kitchen, Martin. "The Political History of Clausewitz." The Journal of Strategic Studies Volume 11, Number 1 (March 1988): 27-50.

Laing, Jonathan R. "Efficient Chaos: Or, Things They Never Taught in Business School." Barron's Volume 71, Issue 30 (July 29, 1991): 12-13.

Libicki, Martin. "Silicon and Security." Strategic Review Volume XX, Number 3 (Summer 1992): 62-65.

Maass, Peter. "A Cry for Help From a Frozen Hell." The Washington Post, 13 January 1993, pp. A-1 & A-16.

Macgregor, Douglas A. "Future Battle: The Merging Levels of War." Parameters Volume XXII, Number 4 (Winter 1992-93): 33-47.

Mann, Steven R. "Chaos and Strategic Thought." Parameters Volume XXII, Number 3 (Autumn 1992): 54-68.

Morlan, MAJ Bruce W. "Data Fusion," in Critical Technologies for National Defense, Przemieniecki, J.S., editor. Washington, D.C.: American Institute of Aeronautics and Astronautics, 1991.

Nelan, Bruce W. "A Friend in Need." TIME, 5 April 1993, pp. 22-27.

Page, Clarence. "Worrisome T.V. Role in Fashioning Foreign Policy." Kansas City Star, 10 December 1992, pg. C-5.

Polk, Peter B. and Gary A. Lee. "Battlefield Management System: Data Requirements to Support Passage of Company Level Tactical Information." (Monterey, California: Naval Postgraduate School, March 1987).

Powell, General Colin. "Information-Age Warriors." BYTE Volume 17, Number 7 (July 1992): 370.

Priesmeyer, Richard H. and Jack Davis. "Chaos Theory: A Tool for Predicting the Unpredictable." Journal of Business Forecasting Volume 10, Issue 3 (Fall 1991): 22-28.

Priesmeyer, Richard H. and Kibok Baik. "Discovering the Patterns of Chaos - A Potential New Planning Tool." Planning Review Volume 17, Issue 6 (November/December 1989): 14-21.

Ruthen, Russell. "Adapting to Complexity." Scientific American Volume 268, Number 1 (January 1993): 130-140.

Shaw, Robert. "Strange Attractors, Chaotic Behavior and Information Flow." Zeitschrift fuer Naturforschung Volume 36a (1981): 80-112.

Smith, Douglas. "How to Generate Chaos at Home." Scientific American Volume 266, Number 1 (January 1992): 144-146.

Stewart, Ian. "Does Chaos Rule the Cosmos?" Discover Volume 13, Number 11 (November 1992): 56-63.

Stewart, Ian. "Christmas in the House of Chaos." Scientific American Volume 267 Number 6 (December 1992): 144-146.

Government Documents

United States Army. Field Service Pocket Book, 1917. Washington, D.C.: U.S. Government Printing Office, 1917.

United States Army. Field Manual 100-5 -- Operations (Final Draft). Washington, D.C.: U.S. Government Printing Office, 19 January 1993.

United States Department of Commerce. Report of the National Critical Technologies Panel. Arlington, Virginia: U.S. Government Printing Office, March 1991.

United States Department of Defense. Critical Technologies Plan. Washington, D.C.: U.S. Government Printing Office, 15 March 1990.

United States Department of Defense. Conduct of the Persian Gulf War Pursuant to Title V of the Persian Gulf Conflict Supplemental Authorization and Personnel Benefits Act of 1991. Washington, D.C.: U.S. Government Printing Office, April 1992.

United States General Accounting Office. Defense Industrial Base: DoD Needs Better Method of Identifying Critical Technology Funding. Washington, D.C.: U.S. Government Accounting Office, February 1992.

United States General Accounting Office. Defense Industrial Base: Industry's Investment in the Critical Technologies. Washington, D.C.: U.S. Government Accounting Office, February 1992.

United States General Accounting Office. Defense Industrial Base: DoD's Manufacturing Technology Program Needs Systematic Evaluation. Washington, D.C.: U.S. Government Accounting Office, March 1992.

United States General Accounting Office. Defense Technology Base: Risks of Foreign Dependencies for Military Unique Critical Technologies. Washington, D.C.: U.S. Government Accounting Office, March 1992.

United States Marine Corps. FMFM 1 – Warfighting. Washington, D.C.: Headquarters, U.S. Marine Corps, 1989.

Monographs

Cox, Robert D. "Information Pathology and the Army Tactical Command and Control System (ATCCS): Is ATCCS a Cure?" School of Advanced Military Studies onograph. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1990. (ADA 233 309).

Gilbert, Daniel J. "Brigade C2: Is the Current System Too Complex?" School of Advanced Military Studies Monograph. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1988. (A 208 257).

Krysa, John C. "Tactical Command and Control in the Combined Arms Battalion Task Force." School of Advanced Military Studies Monograph. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1987. (ADA 191 792).

Reese, Robert J. "AirLand Battle and Tactical Command and Control Automation." School of Advanced Military Studies Monograph. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1986. (ADA 192 608).

Rios, Leon H. "Technology, and Tactical Command and Control." School of Advanced Military Studies Monograph. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1985. (ADA 167 709).

Stoner, John K. "Can We Talk? Transformational Leadership and Communications Technology at the Tactical Level of War." School of Advanced Military Studies Monograph. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1992.

Willbanks, James H. "AirLand Battle Tactical Command and Control: Reducing the Need to Communicate Electronically in the Command and Control of Combat Operations at the Tactical Level." School of Advanced Military Studies Monograph. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1984. (ADB 090 215 L).